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ASYMMETRIC INFORMATION IN CREDIT MARKETS AND ITS IMPLICATIONS FOR MACRO-ECONOMICS

By J. E. STIGLITZ* and A. WEISS**

1. Introduction

MORE than 200 years ago, Adam Smith wrote that if the interest rate was fixed too high

... the greater part of the money which was to be lent, would be lent to prodigals and profectors ... Sober people, who will give for the use of money no more than a part of what they are likely to make by the use of it, would not venture into the competition.¹

In Stiglitz-Weiss (1981, 1983), we developed a theory of credit rationing. We argued that banks might not increase the interest rate they charged even in the face of an excess demand for funds, for to do so might reduce their expected rate of return because the probability of default would increase. Two reasons were presented for the possible inverse relationship between the rate of interest charged and the expected return to the bank: higher interest rates reduce the proportion of low risk borrowers (the sorting effect to which Smith had called attention) and higher interest rates induce borrowers to use riskier techniques (the incentive effect).²

We argued that collateral and other non-price rationing devices would not eliminate the possibility of credit rationing. Increasing collateral requirements makes borrowers less willing to take risks, which increases the return to the bank. On the other hand, increasing collateral requirements may adversely affect the mix of applicants.³ Even if all individuals had the same utility functions and faced the same investment opportunities, wealthier individuals would both be willing to put up more collateral and would undertake riskier projects than would less wealthy individuals if there was decreasing absolute risk aversion.⁴ Moreover, if large wealth accumulations are the result of risk-taking plus luck, a disproportionately large fraction of the very wealthy—those who would put

¹ Adam Smith, *Wealth of Nations*, 1776.

² More generally, the higher the interest rate charged, the higher the probability that any particular borrower will not repay, either because he has undertaken riskier actions which (with a higher failure rate) leave him unable to pay back the loan, or because he is willing to bear the costs associated with default (bankruptcy). The latter effect has been investigated in greater detail in the case of sovereign debt. See Eaton and Gersovitz (1981) or Eaton, Gersovitz and Stiglitz (1986).

³ In most other models in this literature, increasing collateral requirements is only helpful (see, for example, Bernanke and Gertler (1988, 1989) and Bester (1985)). The discussion below should make clear why these models are special.

⁴ Subsequently, Wette (1983) showed that if opportunity sets differ across borrowers, not even the assumption of risk aversion is required.

up a large amount of collateral—would be those who were risk-loving (or at least not very risk averse): those who had gambled and won. These negative adverse selection (sorting) effects may dominate the positive incentive effects and the possible positive sorting effects associated with past successes. Lenders would then find that by increasing their collateral requirements beyond some point returns decrease.

We developed our theory as a market explanation of the widely observed phenomena of red-lining and credit rationing. By red-lining we mean excluding certain observationally distinct groups from credit markets, rather than offering members of those groups a contract that demands higher interest payments and collateral requirements. By credit rationing we mean that among observationally identical borrowers some get loans while others are denied credit. Moreover, the excluded loan applicants are strictly worse off than the borrowers who get loans. (As in so many areas in economics, there is not universal agreement about the extent or importance of the phenomenon.)⁵ Our theory did not require recourse to explanations based on institutional considerations or government regulations.⁶

In writing our papers, we attempted to present the simplest models that we thought provided the basic insights into the role of informational asymmetries in credit markets. We analyzed the sorting and incentive effects of loan contracts in isolation. We allowed lenders to vary either the interest rate charged borrowers or the collateral required for loans but not both.⁷

In this paper we analyze a more realistic model of the credit market in which adverse selection and incentive problems are both present, and in which lenders can simultaneously vary collateral requirements and interest rates to affect both the mix of applicants and the incentives of successful loan applicants. We show that despite the richer strategy space available to lenders, the market equilibrium may be characterized by credit rationing in the sense defined earlier. Indeed, every risk class of borrowers may be rationed, and rationing may occur at every contract. The model we construct has several other interesting features: there may exist, for instance, pooling equilibria, ie, equilibria in which high risk and

⁵ The recent empirical work on this issue does suggest that credit market imperfections are important enough that they can be observed in a wide variety of data sets from different countries and industries. For instance, Devereux and Schianterelli (1989), Fazzari *et al.* (1988), Galeotti *et al.* (1990), Hoshi *et al.* (1988), and Hubbard and Kashyap (1989) report evidence of credit rationing in the UK, US, Italy, Japan, and US agriculture respectively. Gilchrist (1989) takes a different approach. He finds that an Euler investment equation is misspecified only for firms that pay low or no dividends. This is further supporting evidence of the significance of credit restrictions.

⁶ The type of credit rationing with which we have been concerned should also be distinguished from the phenomenon that for any borrower the interest rate charged is an increasing function of the amount borrowed. This would be true with full information, provided that as the individual borrows more the likelihood of default increases. It is also true if the {interest rate, loan size} schedule serves as a self-selection device. Our theory attempted to explain why some individuals could not borrow funds at any interest rate, though similar individuals had access to funds.

⁷ Bester (1985, p. 850) asserts that 'no credit rationing will occur in equilibrium if banks compete by choosing collateral requirements and the rate of interest to screen borrowers'. As we show below this assertion is false.

low risk individuals borrow at the same terms. (In standard adverse selection models, such as Rothschild-Stiglitz (1976), pooling equilibria cannot exist.) Though we couch our analysis in terms of the credit market, it should be clear that our analysis, showing the importance of the *interaction* between sorting and incentive effects, has implications for the analysis of other markets as well. In particular, previous analyses (including our own) that have treated only the sorting effects or only the incentive effects of contracts in labor and insurance markets may have generated misleading results.⁸

Perhaps the most important features of our model are its macro-economic implications, both their consistency with observed cyclical variations in real interest rates and their consequences for macroeconomic policy. Our analysis of Section 2 provides, for instance, a way to reconcile the frequent divergence between observed movements in real interest rates and inferred movements in the marginal productivity of capital over the business cycle. Conventional competitive theory suggests that the real (short term) interest rate equals the value of the marginal productivity of capital. With a Cobb-Douglas production function, shocks to the economy which increase (total factor or labor) productivity should, at fixed labor inputs, increase the marginal return on capital (and thus presumably the rate of interest) equi-proportionately; and since in booms, not only does labor productivity increase but labor input also increases, the *increase* in the real interest rate should be all the greater.⁹ Further, if the production function exhibits less than unitary elasticity between capital and labor, as suggested by most econometric evidence, the increase in the real interest should be still larger. Yet, real short term interest rates charged borrowers, or paid depositors, exhibit neither the qualitative nor quantitative variations which such a theory would suggest; in some recessions they even increase.¹⁰ We discuss these and other macroeconomic implications of our model in Section 2.¹¹

⁸ For example, in a recent paper, DeMeza and Webb (1987) only consider the sorting effects of credit contracts. They find that informational asymmetries lead to overinvestment in a model in which the return on safe projects (whether successful or unsuccessful) are the same as those of risky projects. Thus they assume that among observationally identical projects, some stochastically dominate others. Their results also depend on this assumption.

⁹ Jon Fay and James Medoff (1985) cite the 'substantial literature' on the positive correlation between employment and labor productivity over the business cycle. They present firm level data that suggests that this correlation is due to labor hoarding in slumps. We are not concerned with explaining the pro-cyclical pattern of labor productivity; we are rather concerned with why, given the procyclical movement of average, and presumably marginal productivity, real interest rates are not clearly pro-cyclical. The presence of labor hoarding simply implies that the 'true' increase in the labor-capital ratio in booms is greater than the 'observed' increase.

¹⁰ Moreover, the kinds of explanations for deviations from observed average market prices and marginal productivities which are sometimes adduced in other markets—such as the presence of long term contracts—seem unpersuasive in this context. Movements of real interest rates in auction markets, such as the market for government bills, show similar patterns; and to the extent that there are differences, such as loan rates failing to fall as much as *T* bill rates in the Great Depression, the differences are just the opposite from what one would expect from a long term relationship, for they entail a substantial increase in *real* interest rates charged during slumps.

¹¹ One cautionary note is perhaps in order at this point. The equilibria discussed in Section I are not, in general, unique. It is a commonplace observation that in models with multiple equilibria,

Thus, the current paper extends our earlier work in three essential ways: it incorporates *simultaneously* both selection and incentive effects; it considers *simultaneously* both price (interest rate) and non-price (collateral) terms of the loan contract; and it goes beyond the microeconomic implications of our theory of credit for credit rationing and red-lining to analyze the macroeconomic implications, both with respect to cyclical movements of variables, such as the real interest rate, as well as the effectiveness of monetary policy.¹²

1. Microeconomic equilibrium

This section is divided into four parts. The first describes the basic model, the second provides some preliminary analytics, the third describes the market equilibrium and the fourth discusses several extensions of the analysis.

1.1. *The basic model*

The model consists of a description of borrowers and banks and an analysis of their interactions.

(a) *Borrowers.* We assume that the representative borrower has two possible techniques into which he can invest the funds lent by the bank. A project either is successful, yielding a return of R^s or R^r depending on the technique used, with $R^s < R^r$; or is unsuccessful, in which case it has a return of zero. The probability of success of the 'safe' technique is p^s , for the risky, p^r , with $p^s > p^r$. Lenders cannot observe directly which technique a borrower is using. A project

there are problems with comparative statics because the policy change might induce a 'switch' to another equilibrium.

However, if one took this observation to mean that one should never calculate comparative statics for models with multiple equilibria, this would almost always prevent economic models from being used to guide policy. It is unlikely that a reasonable model of the economy can be constructed that does not have multiple equilibria. For example, the economy that we are acquainted with has weekends on Saturday and Sunday. There is undoubtedly another (more or less efficient equilibrium) with weekends on Sunday and Monday. We do not believe that the existence of this other equilibrium precludes economic analysis of the effects of the 1986 tax reforms, or predictions of the effects of a drought on GNP. Nor should the existence of multiple equilibria in our model preclude analyses of past changes in interest rates: the detailed investigation of credit markets that is needed to give our model empirical content would also reveal which equilibria the economy was in.

On the other hand, if it is not implausible that the contemplated policies would change the strategies of banks, moving the economy from one equilibria (such as each bank offering only one credit contract) to a different one (such as one where every bank offers several credit contracts), then that possibility should be acknowledged. While in those circumstances the existence of multiple equilibria still does not foreclose economic analysis, it does introduce an additional form of uncertainty into the analysis—strategic uncertainty in which the market participants are uncertain of what strategies the other participants will be playing.

¹² As in our earlier work, we focus on loan contracts as the source of finance. The evidence of, reasons for, and consequences of limitation on equity markets have been detailed elsewhere; see, e.g. Greenwald, Stiglitz, and Weiss [1984], Myers and Majluf [1984], Greenwald and Stiglitz [1988a,b, 1992], and Stiglitz [1992].

costs a fixed amount, greater than the wealth of any borrower; we normalize this cost at unity. Each borrower can undertake at most one project. (Our results only require that there be a region of increasing returns to scale.¹³ The stronger assumption of fixed project size is made for expositional ease.)

Banks make loan offers characterized by an interest rate r and a collateral requirement C . The borrower has an initial wealth of W_0 ; this is of two forms: collateralizable wealth, C_0 , and non-collateralizable wealth, H_0 . The latter includes pensions, potential inheritances, and human capital. For simplicity, we assume all borrowers have the same utility function. Differences in wealth then induce differences in the indifference curves between the required interest payments on a loan and the required collateral.¹⁴

Similar considerations are germane to an analysis of corporate borrowing. Although corporations do not have non-collateralizable wealth of the form we have discussed, the relevant decision makers in different corporations are affected differently when a corporation goes bankrupt. In the case of large publicly traded corporations the relevant decision maker may have substantial wealth that is not tied to the solvency of the corporation, while the owner-operator of small privately owned corporations may lose a large proportion of his assets in the case of corporate bankruptcy. The proportion of a decision maker's wealth that is linked to the solvency of the corporation, and the opportunities to remove that wealth prior to bankruptcy, are typically not fully known by lenders.

Wealth not invested in the project yields a safe return of i^* . The bank requires the borrower to put up collateral \hat{C} , and to pay interest on its loan of r .¹⁵ (Alternatively, the bank could require the borrower to invest in the project. None of our results would change if the bank required the borrower to put up some of his liquid assets as equity.) Thus, if the project is successful, the end-of-period wealth of the borrower is¹⁶

$$Y_1 = W + R - (1 + r) \quad (1a)$$

¹³ Not even that assumption is required for the analysis. What is required is that there be an initial non-convexity in the function relating expected loan returns to loan size. The incentive compatibility constraints may induce such a non-convexity, even when the underlying production technology is convex. See Stiglitz and Weiss (1981), and Hellwig (1977).

¹⁴ It should be clear that all that is required for the subsequent analysis is that the slopes of these indifference curves differ systematically with wealth. It does not matter whether those differences arise solely from differences in wealth, or from differences in the underlying preferences.

¹⁵ We assume that the loan can only be partially collateralized, i.e. $\hat{C} < 1$, implying that the bank must charge an interest rate $r > i^*$. With full collateral, loans would not be risky, and would accordingly bear the same interest rate as government securities, providing strong evidence that even in the most highly collateralized loans, collateral is limited. What is relevant, from the perspective of the lender, is the value of the collateral in those events when the borrower defaults. These circumstances (as the S&L's in the United States have discovered with a vengeance) are precisely the circumstances when collateral is likely to have a low value, and thus not fully compensate the lender for what is due to him.

¹⁶ More generally, we can write income as a function of R as: $Y = \max\{W + R - (1 + r), W - C\}$.

while, if it is unsuccessful, the end-of-period wealth is¹⁷

$$Y_0 = W - C \quad (1b)$$

where

$$W = W_0(1 + i^*), C = \hat{C}(1 + i^*).$$

The expected utility of a borrower is

$$E\{U\} = U(Y_1)p + U(Y_0)(1 - p).$$

We assume the borrower is risk averse and that there is decreasing absolute risk aversion.¹⁸ The assumption of decreasing absolute risk aversion is important for our analysis since it implies that holding interest rates and collateral fixed, wealthier borrowers choose riskier techniques.

It is clear that, if the borrower has no choice of technique then his indifference curve between collateral and interest is concave, as depicted in Figure 1. If the borrower can only use the safe technique, his indifference curve through any point would be flatter than if he could only use the risky technique. The reduction in interest rate required to compensate the individual for an increase in collateral is smaller, since the probability of losing the collateral (the probability of a default) is smaller. The slope of the indifference curve is

$$-\left. \frac{dr}{dC} \right|_U = \frac{U'_0(1 - p)}{U'_1 p} \quad (2)$$

where

$$U'_i \equiv U'(Y_i) \equiv \frac{dU(Y_i)}{dY_i}, i = 0, 1.$$

The borrower chooses the technique that gives him the higher expected utility. The borrower is indifferent between the two techniques along the locus defined by

$$EU^r \equiv U(Y'_1)p^r + U(Y_0)(1 - p^r) = U(Y'_1)p^s + U(Y_0)(1 - p^s) \equiv EU^s \quad (3)$$

where Y'_1 denotes the end-of-period wealth of a borrower who uses the risky technique and is successful; Y'_1 is defined similarly. Note that Y_0 (end-of-period wealth if the project is unsuccessful) does not depend on the technique used.

¹⁷ We are implicitly assuming that in the case of default the bank can only attach the assets of the borrower that have been put up as collateral. We would argue that this is realistic both for the case of individuals and corporations. Typically even unsecured loans that are a small fraction of a borrower's wealth demand much higher interest rates than secured loans. This is because the post-default bargaining position of a bank is seriously affected by whether it has physical possession of sufficient collateral to cover the debt. If the bank needs to sue for wealth that has not been put up as collateral there are many opportunities for the borrower to avoid payment. In the case of corporations typically stockholders get some share of the assets in the case of bankruptcy even when unsecured debtors are getting less than the full value of their debt. The formulation in (1) implicitly assumes that while the bank holds the collateral, it earns an interest rate of i , which is returned to the borrower if he repays the loan and is appropriated by the lender if he does not.

¹⁸ That is, we assume $U' \geq 0$, $U'' \leq 0$, and $dA/dY < 0$, where $A = -U''/U'$.

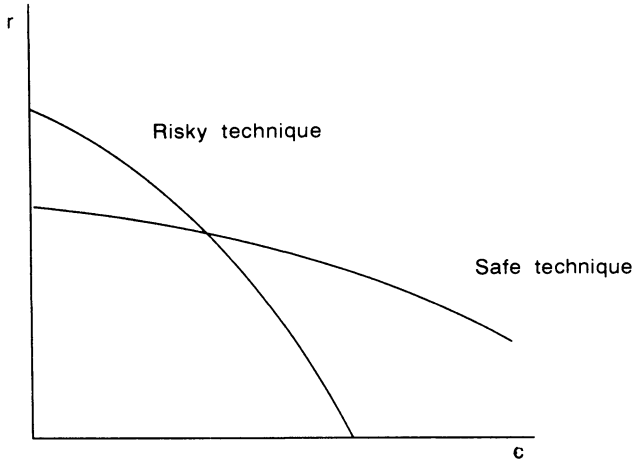


FIG. 1a. Indifference curves

Of two individuals with the same wealth, the one with the riskier technique has a steeper indifference curve. With a single activity, indifference curves are downward sloping and concave.

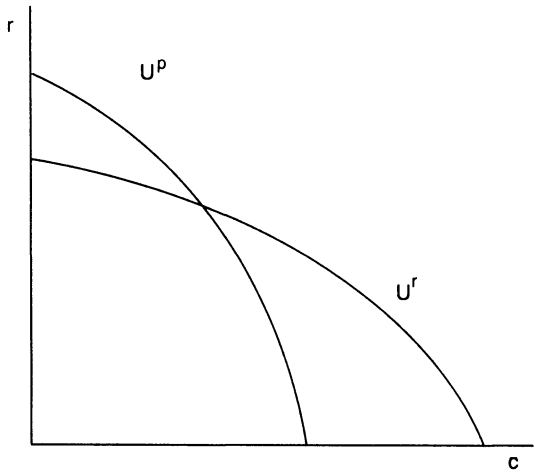


FIG. 1b. Indifference curves

A rich individual has a flatter indifference curve than a poorer individual; he requires a smaller reduction in the interest rate to compensate him for an increase in collateral.

The locus of $\{C, r\}$ combinations satisfying (3) is called the *switch line*. The switch line is positively sloped:

$$\left. \frac{dr}{dc} \right|_{EU^r = EU^s} = \frac{U'(Y_0)(p^s - p^r)}{U'(Y_1^s)p^s - U'(Y_1^r)p^r} > 0. \tag{4}$$

Above the switch line the borrower uses the risky technique; below it, where interest rates are low and collateral requirements are high, the borrower uses

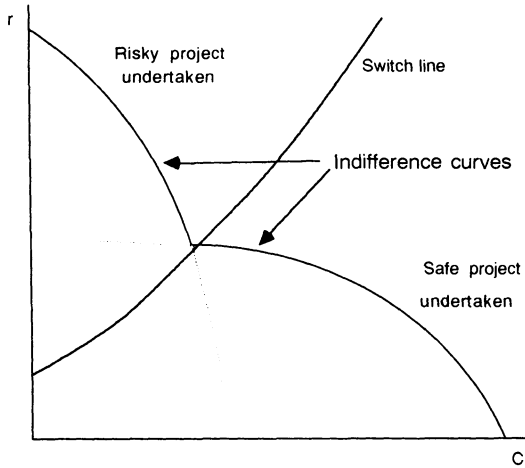


FIG. 2a.

The switch line gives those {interest rate, collateral} pairs at which the borrower is indifferent between undertaking the safe and risky projects. It is upward sloping.

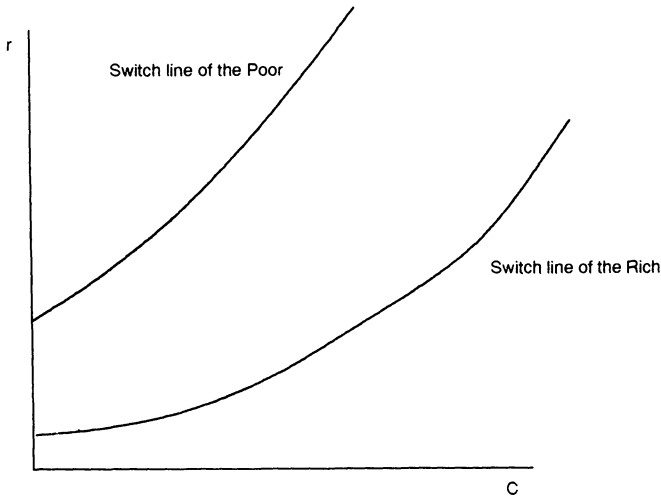


FIG. 2b.

The switch line of the poor lies above that of the rich.

the safe technique. Thus, by specifying C and r , the bank can indirectly control the technique used by the investor.

Note that the indifference curves of the individual—taking into account the changes in technique choices which occur as C and r change—are not concave. They appear as in Figure 2, with the indifference curve above the switch line being discretely steeper than below it, reflecting the higher probability of failure. (Recall from (2) that the slope of the indifference curve depends on the ratio of the probability of failure to the probability of success and on the ratio of

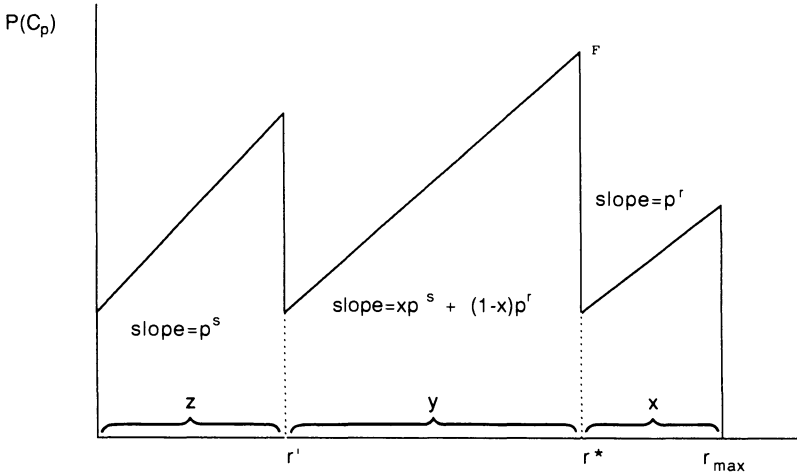


FIG. 3.

Collateral fixed at C_p
 At r^* , rich switch to risky project
 At r^* , poor switch to risky project
 Above r_{\max} no one borrows
 x = fraction of those borrowing at C_p who are poor

U'_0 to U'_1 , both of which change discretely, and in the same direction, at the switch line.)

In this paper, we assume there are two types of individuals who differ only in their wealth. Denoting the rich with subscript r , and the poor with a subscript p ,

$$W_p < W_r, C_p < C_r.$$

Our assumption of decreasing absolute risk aversion implies that *the switch line for the rich lies everywhere below the switch line of the poor*.¹⁹ Thus, in Figures 3–6, we identify three regions: for contracts in region X, both the rich and poor use the risky technique; in region Z both use the safe one; in region Y, the poor use the safe technique and the rich the risky technique.

The indifference curve of the rich through any point in the region X or Z (where they both use the same technique) (Figure 6) is always flatter than that of the poor; they need less of a reduction in interest charges to compensate them for any increase in collateral, given that they use the same technique. But

¹⁹ Consider a rich individual offered a contract along the switch line. A switch from the safe to the risky technique can be viewed as a mean utility preserving change, in the sense of Diamond and Stiglitz (1977). Hence we know from Diamond and Stiglitz that a mean-utility preserving change for one individual induces a reduction in expected utility for a more risk averse individual (in the Arrow-Pratt sense of absolute risk aversion).

Hence, along the poor individual's switch line

$$EU(Y'_1)p_r + EU(Y_0)(1 - p^r) < EU(Y'_1)p_s + EU(Y_0)(1 - p^s)$$

in region Y , where the rich use the riskier technique and the poor the safer one, the indifference curve of the rich may be steeper than that of the poor.²⁰

(b) *Banks.* Banks are risk neutral. If technique i is used, the expected return to the bank, v , is

$$v = p^i(1 + r) + (1 - p^i)C. \quad (5)$$

For a given project, the iso-return curve is a straight line. As can be seen in Figure 5, the iso-return line below the switch line intersects the switch line at a point southwest of where the iso-return line above the switch line intersects the switch line. This is because of the discrete change in the technique used.²¹

Regardless of whether the individual uses the safe or the risky technique the borrower's indifference curve is steeper than the bank's iso-return locus, because the borrower is risk averse.²²

(c) *Equilibrium.* Banks know that there are poor and rich borrowers, but cannot ascertain who is of which type. They know, however, that the choice of credit contracts—defined here by an interest rate and collateral requirement—may reveal information about who is of which type; the mix of applicants at one contract may differ from the mix at another (clearly any borrower applying for a contract with collateral requirements in excess of C_p must be rich). They also know that contracts have incentive effects, determining whether a rich or poor borrower undertakes the safe or risky project.

In equilibrium, the set of loan contracts offered and loan commitments made by banks, must be such that no bank can increase its profits by offering a different

²⁰ Using (2) in regions X or Z , where the two individuals differ only in wealth,

$$\frac{d \ln U'_0/U'_1}{dW} = \frac{U''_0}{U'_0} - \frac{U''_1}{U'_1} = A_1 - A_0 < 0$$

with decreasing absolute risk aversion.

In Region Y , while for the rich, $(1 - p)/p$ is higher, U'_0/U'_1 will be smaller.

²¹ Formally at the switch line, the choice of technique is unrestricted by notions of dominance or any of the equilibrium refinements. (The individual is indifferent as to which technique he employs.) Accordingly, we can assume that on the switch line the borrower is undertaking the safe project with some probability. For each point on the switch line there is some probability of undertaking the safe project, such that the expected return to the bank is \bar{v} . In this sense, then, the iso-return curve to the bank, though peculiarly shaped, is not necessarily discontinuous. It follows the switch line connecting the straight lines in Figure 3. However, as will be apparent below if a pooling or complete separating equilibrium exists it is characterized by all those borrowers who are indifferent between safe and risky projects choosing the safe projects.

$$\left(\frac{dr}{dC} \right)_{\bar{v}} = \frac{-(1 - p^i)}{p^i}$$

which is always less than the slope of the indifference curve given by (2) since $Y_1 > Y_0$ and $U'' < 0$.

contract or a different mix of contracts, or changing the number of loan commitments it is making.²³

The interest rate paid depositors elicits a supply of loanable funds equal to the equilibrium quantity of loan acceptances.²⁴ In this paper, we do not formally model the supply function of funds, simply hypothesizing that it is an increasing function of the interest rate paid depositors (i): $L = L(i)$, $L'(i) > 0$. We assume banks are sufficiently small that no bank affects the interest rate paid depositors.²⁵ We also assume that each bank is large enough that its probability of bankruptcy is negligible. (These two assumptions are consistent, provided the economy is large enough.)

1.2. *Some preliminaries*

Several properties of the equilibrium may easily be derived. First, in equilibrium, each bank earns zero profits. If a bank earned negative profits it would not make any loans. If any bank made positive profits some other bank would offer a slightly more attractive set of contracts, one that attracts all the borrowers that were previously getting loans and does not change the choices made by those borrowers.²⁶ It follows that in equilibrium, the rate of interest paid depositors must be equal to the expected return on a loan contract.

We denote by $v_x\{K\}$ the expected return to the bank from contract K when a fraction x of those taking it are poor; v_1 is the expected return when only

²³ Formally, we can describe interactions of banks and borrowers in terms of a game. We use the Kreps-Wilson definition of a sequential equilibrium, and do not allow (weakly) dominated strategies to be played in equilibrium.

The actions of borrowers and lenders follow a sequence of moves which can be broken down into five stages. In the first stage, banks choose contracts to offer. In the second stage, borrowers apply for loans. A borrower cannot apply for a loan contract that requires more collateral than the borrower has. In the third stage, banks make loan commitments—accept borrowers. In the fourth stage, borrowers accept from among the contracts that they were offered the one that gives them the highest expected utility. If borrowers are offered several loans that give them the same utility, they randomize their choices.

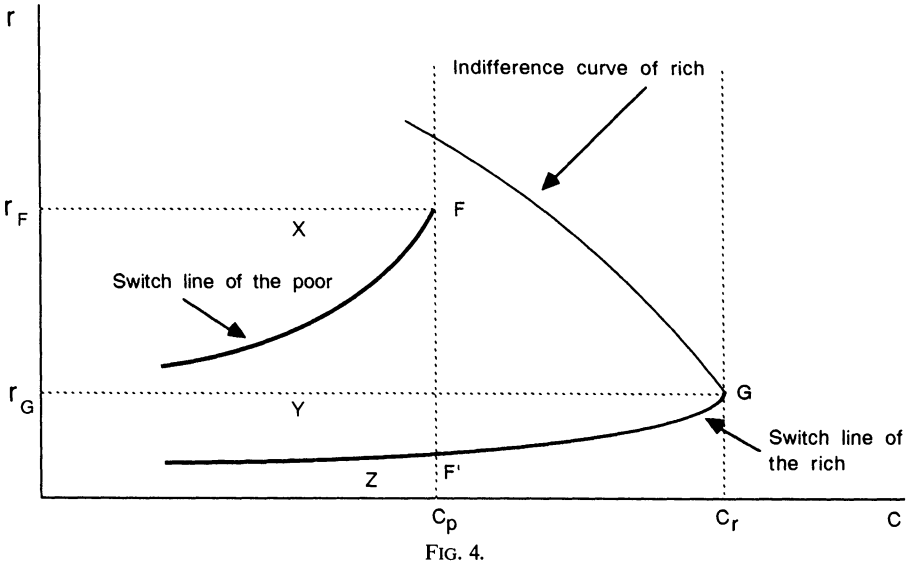
In the final stage of the game, borrowers choose the investment project that maximizes their expected returns given their loan contracts. For simplicity, we assume banks do not observe the contracts offered by their rivals and hence their offers cannot be contingent on others' (unobservable) contracts.

We could alternatively have assumed that banks can observe the contracts offered by other banks when determining the quantity of loans to make. Assuming that contracts are not observed allows us to use the Nash definition of equilibrium and still ignore out-of-equilibrium moves such as threats of the form 'if you offer an attractive loan contract I'll make so many loans that the interest rate paid depositors will be so high that we shall both lose money'. If contracts offered by other banks are observed then we would have to require that equilibria satisfy subgame perfection to eliminate these unreasonable threats.

²⁴ Alternatively, we could have included an auction for deposits as a formal part of the game. However, adding bids for deposits to the action space of lenders increases the complexity of the model without substantively changing the results.

²⁵ Alternatively, we could have assumed that the interest rate paid depositors is set before loan commitments have been made.

²⁶ This follows from the fact that reducing collateral requirements and interest rates in such a way as to leave incentives unchanged has positive selection effects.



F is the optimal contract to the poor
 G is the optimal contract to the rich
 If there exists a pooling equilibrium, it must lie at F.

the poor take it. In the obvious notation

$$v_1\{K\} = v_p\{K\} \text{ and } v_0\{K\} = v_r\{K\}.$$

We denote by contract $\{F\}$ the contract with $C = C_p$ and the highest interest rate consistent with the poor using the safe technique. Contract $\{G\}$ is the contract with $C = C_r$ and the highest interest rate consistent with the rich using the safe technique. (See Figures 4 and 6.)

Let N_r and N_p denote the number of rich and poor investors; $N = N_p + N_r$, and $z = N_p/N$. Then $v_z\{F\}$ is the expected return to the bank on contract F when it is obtained by poor and rich borrowers in the proportion that they are in the population as a whole.

We denote the maximized expected utility of type i with contract K as $U^i\{K\}$. Since only rich borrowers can choose contract $\{G\}$ we write $v_0\{G\}$ as $v(G)$; $v_p\{F\}$ may be either greater or less than $v(G)$. The collateral requirement is higher at G than at F and this increases the bank's expected return; but the interest rate may be lower (because the rich borrower's switch line lies below that of the poor).²⁷

²⁷ Obviously, if the interest rate at G is greater than at F (or not much less), then bank profits at G exceed those at F . Increases in the collateralizable wealth of the rich have two effects: the switch line is shifted down, which decreases the bank's profits; while the direct effect of more collateral serves to increase the bank's profits. The net effect is ambiguous, and depends on the extent to which (absolute) risk aversion decreases with wealth and on the relative differences between the collateralizable and non-collateralizable wealth of the rich and poor. If there is constant absolute risk aversion, then the switch lines would coincide; by continuity, with slightly decreasing absolute risk aversion, the bank's return at G always exceeds that at F . The converse will be true if there is strongly decreasing absolute risk aversion, and the difference in non-collateralizable wealth between the rich and poor borrowers is large relative to the difference between their collateralizable wealth.

1.3. *Equilibrium with incentive and sorting effects*

For simplicity of exposition, we focus in the text on the case where each bank can issue only one loan contract. In Appendix C, we consider the more general case. (The equilibria that we describe turn out also to be equilibria if each bank is allowed to issue more than one contract, but with this wider set of available strategies, there may be other equilibria as well.)²⁸

There may exist reasonable equilibria with and without rationing. Either may be characterized by complete pooling (all rich and poor borrowers receiving the same contract) or by partial separating (at least some of the rich borrowers receiving loans at different contract terms from those received by the poor borrowers).

1.3.a. *A pure pooling equilibrium with rationing*

We first show that if there is a pure pooling equilibrium with rationing, it must be at $\{F\}$, the contract requiring C_p of collateral, and offering the highest interest rate at which the poor borrowers invest in the safe project. We shall assume that profits (per dollar loaned) at F when the fraction of the poor equals or exceeds z are higher than at any contract where the borrowers use the risky technique.²⁹ Hence, we can exclude every contract in region X of Figure 4 from being a pooling equilibrium with rationing. Since $\{F\}$ generates higher profits than (other) contracts in region Y , those contracts also can be excluded as candidates for pooling equilibria with rationing. Finally, no contract in region Z can be a pooling equilibrium with rationing because contract $\{G\}$ generates strictly greater profits than do those contracts. Thus, rationed borrowers would be offered contract $\{G\}$ and the bank making that offer would make positive profits.

There is a pooling rationing equilibrium at $\{F\}$ if and only if the following conditions are satisfied:

- (a) $v_1(F) > v(G)$, profits at F (with pooling) are higher than at G
- (b) $L(v_z(F)) < N$, the supply of funds at $\{F\}$ is less than the demand.

²⁸ In the case where each bank can issue only one contract the five stage game described in the earlier footnote reduces to a single stage. This makes the analysis much simpler, and avoids the controversies associated with the use of alternative refinements in extensive form games.

To see this, first note that even without this restriction, the five stage game can be reduced to a three stage game. This is because whatever beliefs borrowers have, their actions in the fourth and fifth periods are automatic. They choose the best contract offered to them, and given that contract, they choose the technique that maximizes their expected utility.

When lenders offer only a single contract, once a contract is offered the reactions of borrowers are automatic (except when they are indifferent between two projects). The only undominated strategies are ones in which borrowers apply for every contract that makes them better off than not borrowing. Because loan applications to one bank are not observed by other banks, the loan a borrower received from any bank would not be changed by his applications to another bank. By the same token, *given* the actions of the other banks, each bank simply chooses the loan contract that maximizes its expected profits per dollar loaned. Thus, the entire five stage game is reduced to a single stage.

²⁹ That is, $p^r(1 + R') < v_z\{F\}$.

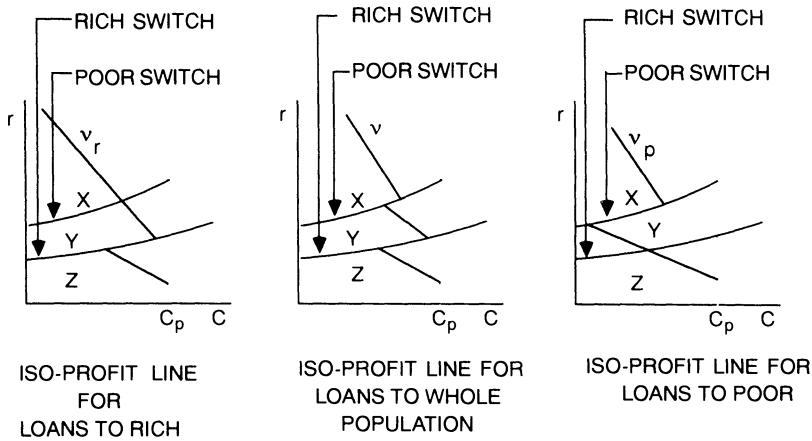


FIG. 5.

To see this, observe that if pooling at $\{F\}$ is an equilibrium, $i = v_z(F)$, and the supply of funds is $L(v_z\{F\})$. Hence rationing at F will occur if and only if condition (b) is satisfied.

To show that 'all banks offering F ' is a rationing equilibrium, consider a deviation from $\{F\}$ by some bank offering a single contract rather than $\{F\}$. If the bank offers a contract with $C > C_p$, clearly only the rich will undertake it. The contract that maximizes the return from the rich, assuming that they undertake the safe project, is $\{G\}$. By (a), and the assumption that banks compete for depositors, even if the rich were to accept contract $\{G\}$, the bank would lose money on those contracts. By assumption, the contract that maximizes the return to the risky project (zero collateral) yields a lower return than $\{F\}$,³⁰ and *a fortiori*, the contract that maximizes the return to the risky project, subject to the constraint that it generates a level of expected utility greater than $U^i\{F\}$, must yield a lower return than $\{F\}$.

If $v\{G\} > v_z(F)$, then, because any lender that offered $\{G\}$ would find that some individuals—those who were not offered loans at $\{F\}$ —would accept the contract, a pure pooling rationing equilibrium could not be sustained.

1.3.b. Interior pooling equilibria without rationing

If at contract $\{F\}$, the supply of funds exceeds the demand, ie, $L(v_z\{F\}) > N$, lenders compete for borrowers; they reduce collateral requirements and interest rates charged in such a way as to ensure that poor borrowers continue to undertake the safe project, ie, they offer contracts southwest of F along the switch line of the poor. Let $\{H\}$ denote the contract along the switch line at

³⁰ The fact that the zero collateral contract maximizes the expected return to a risky project follows from the risk aversion of borrowers; any contract with $C > 0$ could be replaced with a contract yielding a higher expected profit, a higher expected utility to the borrower and a smaller value of C .

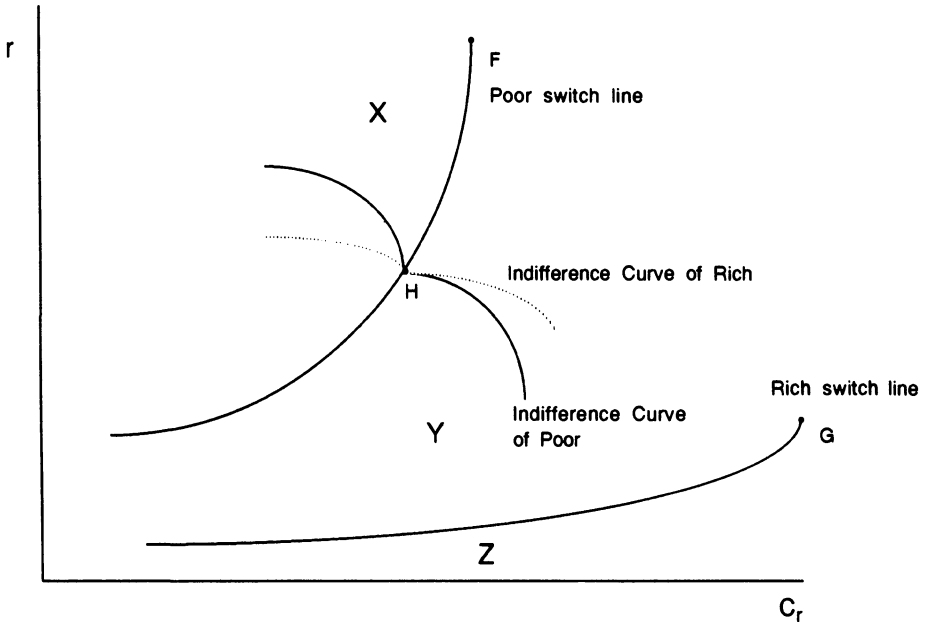


FIG. 6.

which the demand for funds equals the supply. (See Figure 6.) If at $\{H\}$ the return per dollar lent is higher than at the contract $\{G\}$ and if below the switch line (in the region Y) the indifference curve of the poor through $\{H\}$ is steeper than that of the rich, then 'all firms offering H ' is a pooling equilibrium without rationing.

The argument for why this is a pooling equilibrium is the same as earlier, except now we also need to ask, 'Can we find contracts in region Y (below the switch line) but with more collateral which attract only poor customers?' Under the stipulated conditions concerning the slopes of the indifference curves, whenever a contract in v is preferred to $\{H\}$ by the poor (ie, lies below the poor's indifference curve through H) it is also preferred by the rich (ie, lies below their indifference curve through H). Because of decreasing absolute risk aversion, the indifference curves of the rich may well be flatter than those of the poor in region Y , even though the rich are choosing the riskier technique.

Hence, we have established the possibility of *interior* pooling equilibria, where borrowers do not put up all their collateralizable wealth as collateral: there exists an interior pooling equilibrium without rationing at H if and only if

- (a) $L(v_z\{F\}) > N$ (at F there is an excess supply of credit) and $L(v_z\{H\}) = N$
- (b) For all $\{r, C\}$ such that
 - (i) $U^p\{r, C\} > U^p\{H\}$,

- (ii) $C < C_p$, then
 $U^r\{r, C\} > U^r\{H\}$
 (infeasibility of profitable separation)
- (c) $v\{H\} > v\{G\}$ (H is more profitable than G).

1.3.c. A partial pooling–partial separating equilibrium with rationing

There are also rationing equilibria in which some of the rich and poor borrow at the same terms, while some rich borrowers accept contracts that are not chosen by any poor borrowers.

Suppose:

- i) the rich borrowers prefer contract $\{G\}$ to contract $\{F\}$, that is,
 $EU^r\{G\} > EU^r\{F\}$
- ii) $v_x(F) < v(G) < v_1(F)$
- iii) $L(v(G)) < N$.

There is a rationing equilibrium in which some banks offer contract $\{F\}$ and others offer contract $\{G\}$. All the rich borrowers apply for loans at every bank offering either contract $\{G\}$ or $\{F\}$. A rich borrower only accepts a contract $\{F\}$ offer if he is not offered a $\{G\}$ loan. In equilibrium, the number of rich borrowers getting G loans, N_G , is such that the proportion of poor borrowers, x , among those accepting $\{F\}$ loans satisfies

$$v_x(F) = v(G),$$

so that both contracts offered are equally profitable. By continuity and (ii) there always exists a value of x satisfying this condition.³¹ The number of F loans made, N_F , is such that

$$L(v(G)) = N_G + N_F.$$

If $L(v(G)) > N_G$, $N_F > 0$: both $\{G\}$ and $\{F\}$ are offered, and rationed; while if $L(v(G)) < N_G$, only $\{G\}$ is offered.

While both rich and poor borrowers are rationed the rich borrowers are more likely to get loans than are the poor borrowers.

Proof of equilibrium. To show that it is an equilibrium, all we need to establish is that it does not pay any bank to deviate. First, assume that some bank offering $\{G\}$ should decide to offer $\{F\}$. The change increases the proportion of the rich accepting contract offers at $\{F\}$, and hence lowers the profitability of those loans. Hence, that bank (and all other banks offering $\{F\}$) would find its profits lowered: clearly, it would not pay any bank to do this. Conversely, if any bank offering $\{F\}$ switched to $\{G\}$, the proportion of rich accepting contracts at $\{F\}$ would be lower, and hence profits would be higher. This would thus induce a shift back.

Nor does it pay any firm to offer any other contract. First, consider contracts

³¹ Recall our assumption that banks cannot observe a borrower's application to another bank, or whether a borrower is rich or poor.

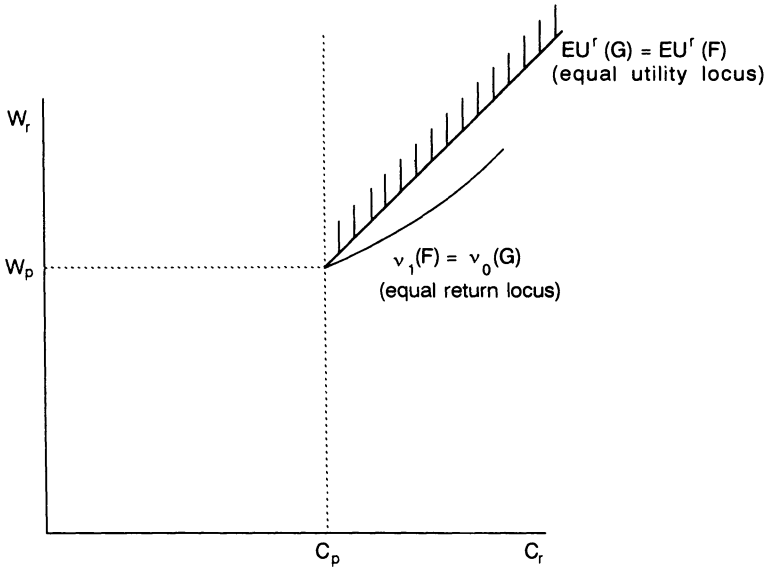


FIG. 7.

Above the equal utility locus, the rich prefer G to F . Above the equal return locus, $v_1(F) > v_0(G)$. Near $\{C_p, W_p\}$ the equal return locus lies below the equal utility locus. The shaded area gives, for fixed collateralizable and noncollateralizable wealth of the poor, the set of collateralizable wealth levels of the rich for which there exists a separating equilibrium.

with $C > C_p$. These will only be taken up by the rich, and the most profitable of such contracts is $\{G\}$. Next, consider contracts with $C \leq C_p$. The most profitable of such contracts in region Y is clearly $\{F\}$. And in region X , both groups use the risky technique, and accordingly the returns to the bank are lower.

Proof that partial pooling-partial separating equilibrium can arise. A natural question is whether the inequalities $v_1\{F\} > v\{G\} > v_z\{F\}$ and $EU'\{G\} > EU'\{F\}$ are consistent with one another. With (sufficiently) decreasing absolute risk aversion and (sufficiently) large differences in non-collateralizable wealth, the switch line of the poor is moved up relative to the rich enough that both $v_1\{F\} > v\{G\}$ and $EU'\{G\} > EU'\{F\}$. In Figure 7 we depict, for fixed collateralizable and non-collateralizable wealth of the poor and given decreasing absolute risk aversion utility functions, the set of collateralizable and non-collateralizable wealth levels of the rich for which there may exist a partially separating equilibrium.³²

³² The proof proceeds first by expressing the contract $\{G\}$ as a function C_r and W_r . Then $v_1\{F\} = v_0\{G\}$ and $EU'\{G\} = EU'\{F\}$ can be viewed as defining implicit relations between W_r and C_r . We evaluate the derivative dW_r/dC_r at $\{C_p, W_p\}$, and show that the equal return locus lies below the equal utility locus, and both loci have positive, finite slopes. Since for a partial-pooling equilibrium, endowments must lie above the equal utility locus (so the rich prefer G to F) and above the equal return locus (so the return to loans to the poor only at F yield higher returns than to the rich at G), the relative slopes of the loci ensures that there exist endowments supporting partial-separating equilibria with rationing. For a proof, see J. E. Stiglitz and A. Weiss, (1985).

1.3.d. Other equilibria

The forms of equilibria on which we have focused are not the only possible ones. There is also, for instance, a (trivial) separating equilibrium with rationing in which only contract $\{G\}$ is offered, and some, but not all, of the rich borrowers get loans at $\{G\}$. The poor borrowers would, of course, be unable to get loans.

There may also exist equilibria with rationing at one contract, but not at another. Suppose there exists a contract H , lying along the rich individual's switch line, with $C_r > C(H) > C_p$, such that

$$v(H) = v_z(F), \quad U'(F) > U'(H), \quad \text{and} \quad N' < L(v_z(F)),$$

then there exists an equilibrium in which all borrowers apply for loans at F and rejected rich borrowers borrow at H ; there may be rationing at F but there will not be rationing at H .

The reasoning is as follows: any rich borrower that gets a loan at F takes it. A lender offering a contract southwest of F or H would incur losses; a contract northeast of H would not attract any borrowers, a contract northeast of F would only attract rich borrowers and, hence, losses.

There are also equilibria in which each bank offers several contracts.

1.3.e. Interpretation and comments on equilibria

(a) A given market can either have a pure pooling rationing equilibrium or a partially separating rationing equilibrium, but not both. This follows from the fact that the pooling equilibrium with rationing requires $v\{G\} < v_z\{F\}$, the partially separating equilibrium requires that $v\{G\} > v_z\{F\}$.

(b) Note that this analysis differs from the earlier Rothschild-Stiglitz-Wilson analyses in several fundamental ways. First, we have *both* adverse selection (sorting) and moral hazard (incentive) problems. Second, because of the incentive effects of contracts, there may exist pooling equilibria (even at interior points in the contract space). Third, in the R-S-W analyses, equilibrium is fully revealing, and there is no rationing. Here, in both the pure pooling and in the partially separating equilibria, we do not obtain full revelation, while we do obtain rationing. This is in spite of the fact that we have enriched the 'strategy' space to allow simultaneous use of both interest rates and collateral requirements, and to allow banks to offer several contracts.

1.4. Some extensions

1.4.a. Differing sets of feasible techniques

Allowing the set of feasible techniques to differ across borrowers, makes our results easier to obtain. This can be seen by observing that the conditions for a pure pooling equilibrium with rationing are certainly more readily satisfied if the set of techniques available to the poor borrowers stochastically dominates

the techniques available to rich borrowers. In that case, a lender would be less likely to increase collateral as a means of eliminating rationing.

1.4.b. *Continuum of projects*

Allowing each type of borrower to choose from a continuum of projects, rather than just two projects requires a slight change of notation, but otherwise does not substantially affect our results. In the case of a pure pooling equilibrium, we define $r^*[z, C]$ as the interest rate at which the bank's expected return per dollar loaned is maximized when it requires C_p of collateral on loans to a proportion z of poor borrowers. If the return on contract (r^*, C_p) exceeds the maximum return on a loan to a rich borrower, and there is an excess demand for credit when contract $\{r^*, C_p\}$ is offered, then there is a pure pooling equilibrium with all banks offering contract $\{r^*, C_p\}$. Similar arguments can be made for extending our construction of partially separating contracts and completely separating contracts with rationing to the case where a continuum of techniques is available to borrowers.

1.4.c. *Many types of borrowers*

Our model, in which each type of borrower has a different endowment of collateralizable wealth, may also be directly extended to the case of many types of borrowers. The analyses of pure pooling and the separating equilibria with rationing follow directly from our analysis with two types. In the pure pooling equilibrium all borrowers again choose contract $\{F\}$.

In the case of a partial pooling equilibrium, we begin with the wealthiest types, and assume that in equilibrium, among the contracts which are feasible for the richer borrowers, they prefer the higher collateral contracts. The contract $\{G_1\}$ that maximizes the return for loans to the wealthiest borrowers determines the return $v(G_1)$ for all other loans. The proportion of the wealthiest borrowers that get loans at contract $\{G_1\}$ is just sufficient to ensure that the bank's maximum expected return on loans at a contract requiring collateral equal to the collateralizable wealth of the next wealthiest borrowers is equal to $v(G_1)$. Denoting that contract by $\{G_2\}$, the proportion of applicants getting loans at contract $\{G_2\}$ is such that the maximum return from loans at a contract requiring collateral equal to the collateralizable wealth of the third wealthiest borrowers is also equal to $v(G_1)$. This process continues through all types. It is easy to specify supply curves for loanable funds and return functions for different types of borrowers that will generate rationing of each type of borrower.

1.4.d. *Additional instruments*

Collateral is just one of the instruments by which banks attempt to select among applicants and to provide incentives for borrowers to undertake safer projects. Other instruments face similar problems in combining conflicting incentive/selection effects, or in any case, are sufficiently ineffective as to leave

a residual incentive/selection problem of the kind with which we have been concerned here.

2. Macro-economic implications

In this section, we explore the macro-economic implications of credit rationing. We address three issues: (a) the consequences of a shift in returns to different projects, such as might occur over the business cycle (Section 2.1); (b) the consequences of a shift in the supply of funds (Section 2.2); and (c) the implications of credit rationing for monetary policy (Section 2.3). Macro-economic analyses that make use of the concept of the 'representative' firm and the representative consumer cannot adequately address macroeconomic problems that arise from imperfect information (where heterogeneity is central). The models we present are intended to be the simplest ones within such problems can be addressed.

2.1. *Analyses of cyclical variability in interest rates: Effects of changes in productivity*

Traditionally, theoretical analyses of cyclical variations in a market consist (in large part) of determining the equilibrating responses in prices (interest rates, wages) and quantities to particular disturbances to demand and supply in various markets. Our theory implies that changes in (real) interest rates charged investors cannot be inferred from an analysis simply of changes in demand and supply for funds. This ambiguity holds even if credit is not being rationed.

Our analysis identifies as critical determinants of the real interest rate charged borrowers the probabilities of success of risky and safe projects. Both probabilities are likely to change over the cycle (as reflected, for instance, in the marked cyclicity of bankruptcy rates). What turns out to be crucial are the *relative* changes. Our model is consistent with a wide variety of patterns of cyclical movements in interest rates charged, interest rates received, and in the degree of rationing. It is consistent, in particular, with real interest rates charged borrowers rising in recessions while that paid depositors falls. To see this, however, we first need to study the consequences of proportionate changes in success probabilities.

In the preceding section, we showed that equilibria could take on several different forms. Because banks do offer a variety of loan contracts with different collateral requirements, we believe that the partial separating/pooling equilibrium provides the best description of the market. We showed that in such an equilibrium there can be (but, not necessarily is) credit rationing at every contract (loan type).³³ The analysis of that case is, however, far more

³³ There can also be partial separating/pooling equilibria without rationing. Many of the comparative statics propositions we are about to derive hold in either regime. We focus on the rationing regime partially because of its (relative) analytical simplicity.

tedious than that for pooling equilibria. Accordingly, we present the results for pooling rationing equilibria, and simply summarize the results (presented in Appendix A) for the partial separating/pooling equilibria.

2.1.a. *Balanced changes in success probabilities*

Assume that the probability of success of both the safe and the risky techniques of production are changed in the same proportion. For simplicity, we write

$$p^{s*} = \beta p^s, p^{r*} = \beta p^r, \beta > 0.$$

β varies procyclically, e.g. $\beta > 1$ in a boom < 1 in a recession. Then, rewriting equation (3), describing the switch line,

$$[U(Y_1^s) - U(Y_0)]p^{r*} = [U(Y_1^s) - U(Y_0)]p^{s*} \quad (8)$$

we immediately see that the switch line is unaffected. It thus follows that *if there is a pooling equilibrium with rationing, the rate of interest and the collateral requirement will remain unchanged*. But since the expected return to the bank (and hence the interest paid to borrowers) is equal to

$$i \sim \bar{v} \equiv \hat{p}(1 + r) + (1 - \hat{p})C_p$$

(where $\hat{p} = zp^s + (1 - z)p^r$, the mean probability of success), i is increased by an increase in β . Given $L'(i) > 0$ the supply of funds is increased. Hence if the demand for funds is unchanged, the incidence of credit rationing is reduced as the economy goes into a boom. Of course, in practice, over the business cycle, the demand for loans is likely to vary markedly as well, and whether in practice the extent of rationing increases or decreases in booms depends on the relative movements of the demand for funds and the supply. Either is, on *a priori* grounds, possible.

2.1.b. *Unbalanced changes in success probabilities*

Assume now, however, that as the economy goes into a recession, risky projects have a disproportionate increase in their probability of failure, and in a boom, they have a disproportionate increase in their probability of success. We write

$$p^{s*} = \delta \beta p^s, p^{r*} = \beta p^r.$$

We adopt the convention that $\beta > 1$ in a boom, $\beta < 1$ in a recession, and

$$0 > \frac{d \ln \delta}{d \ln \beta} > -1$$

that is, the probability of success of a safe project falls in a recession (but less than that of a risky project) and increases in a boom (but again, less than that of a risky project).

An increase in δ shifts the switch line. The equation for the switch line can

now be written

$$[U(Y_1') - U(Y_0)]p' = [U(Y_1^s) - U(Y_0)]\delta p^s \quad (9)$$

since by definition of a safe and risky project $\delta p^s > p'$, this implies that

$$dr/d\delta|_{EU^R = EU^s} = \frac{-[U(Y_1^s) - U(Y_0)]p^s}{U'(Y_1')p' - \delta U'(Y_1^s)p^s} > 0 \quad (10)$$

i.e. the switch line shifts up in a recession as the risky project becomes relatively less attractive, down in a boom. Thus, in the pooling equilibrium, provided risky projects exhibit more cyclical volatility than do safe projects, interest rates charged borrowers will move in a counter-cyclical manner.

Even more surprising is the result that for *sufficiently 'unbalanced' changes in productivity*, the interest rate paid depositors may actually fall in a boom. That is, recalling our definition of \hat{p} as the mean probability of success in a pooling equilibrium, and evaluating v at the pooling equilibrium at F ,

$$\beta \frac{dv}{d\beta} = \left(\hat{p} + \frac{\partial \ln \delta}{\partial \ln \beta} \beta \delta z p^s \right) (1 + r_F - C_p) + \hat{p} \frac{\partial \ln \delta}{\partial \ln \beta} \frac{dr}{d \ln \delta} < 0, \text{ if}$$

$$\left| \frac{\partial \ln \delta}{\partial \ln \beta} \right| > \frac{1}{\frac{d \ln (1 + r_F)}{d \ln \delta} \frac{1}{1 - C_p/1 + r_F} + \frac{z p^{s*}}{\delta z p^{s*} + (1 - z) p^{r*}}}$$

where

$$\frac{dr_F}{d\delta}$$

is the change in the interest rate of contract $\{F\}$ induced by a change in δ , (given by (10)). When v decreases and r_F decreases, the magnitude of credit rationing will increase in a boom.³⁴

It is thus apparent that our model is consistent with a variety of patterns of cyclical movements of the extent of credit rationing and interest rates paid and charged. Our model is, in particular, consistent with the fact that interest rates are far less volatile than the returns to equity.

2.2. Changes in the supply of funds

One of the reasons for our interest in credit rationing is that it raises the possibility that the way that the central bank affects the level of economic activity is not through changes in the interest rate but through changes in credit availability.

In this section, we trace out the consequences of an outward shift in the supply function of resources available to be lent.

As more resources become available, the number of projects undertaken increases, but the average interest rate charged may remain unchanged (in the

³⁴ We are taking the normal case where the supply of loanable resources is an increasing function of the interest rate paid depositors.

pooling equilibrium) or may actually *increase* (in the separating or partially separating equilibrium). To see how an increase in the supply of loanable resources could increase the average interest rate charged, observe that an increase in the number of loans made at contract G increases the return to banks from loans at F . Therefore, if returns on the contracts (F) and (G) are to remain the same, the number of loans made at (G) must remain unchanged; small changes in the availability of credit only affect the quantity of low collateral loans. But the interest rate charged on the low collateral loans must exceed that on the high collateral loans, and hence an increase in the supply of loanable resources must cause the average interest rate charged to increase. A fuller analysis of the effects of a change in the supply of loanable resources is contained in Appendix B. There we note too that as the supply curve for funds shifts the nature of the equilibrium (rationing at two contracts, rationing at one contract, no rationing, etc.) may change.

We should emphasize that while a reduction in the available resources reduces investments, the projects which are eliminated are not necessarily those with the lowest expected gross returns, ie, those for which, in our model, pR is lowest.

2.3. *Monetary policy, macroeconomic equilibrium, and credit rationing*

There is a sense in which our model conforms closely to traditional views, and a sense in which it differs markedly.

In traditional Keynesian analyses, an increase in ' M ' (money supply) leads to a reduction in interest rates; the reduction in interest rates leads to an increase in investment; and the increase in investment leads to a higher level of income.³⁵ The traditional analysis was based on a stable relationship between money, income and interest rates, and is usually motivated by some transactions story (ignoring, of course, the fact that most transactions, in dollar terms, are trades in assets, and there is no *a priori* reason for a stable relationship between asset transfers and income flows—on the contrary, there are strong *a priori* reasons that over the business cycle this relationship might change). The traditional analysis also obfuscated which interest rate was relevant, and ignored the fact that, except in certain isolated periods (1930–5, 1980–8) real interest rates—which modern economists would argue are the relevant ones—have varied relatively little (Jaffee and Stiglitz (1989)) and have been negligible relative to the expected returns demanded by firms on their investments.

In our analysis, there are two critical links, one between the money supply, ' M ', and credit availability, A , and another between credit availability and investment. Of course, if, as in simpler versions of our model,

$$A = aM,$$

the available credit (A) is proportional to the money supply, and

$$I = Ab,$$

³⁵ This 'dynamic' interpretation ignores the fact that the interest rate and income are determined simultaneously in the standard model.

investment I is proportional to the supply of available credit, then, if

$Y = \text{Consumption} + \text{Investment} + \text{Government expenditure } (G), \text{ and}$

$C = mY$

then

$$Y = \frac{abM + G}{1 - m},$$

national income increases with money supply, as in conventional monetary models. This is the sense in which our model is similar to standard models.

But it is equally important to note the differences. First, we would argue that the link between ' M ' and ' A ' is likely to change over the business cycle, with an increase in money supply having a relatively weak effect on credit availability in recessionary periods. (For a more extended discussion of the link between M and A , see Blinder and Stiglitz (1983), Bernanke and Gertler (1989) or Greenwald and Stiglitz (1990, 1992b).)

Second, we note that monetary policy can be contractionary (expansionary) even though the average real interest charged borrowers changes little, or indeed decreases (increases). More generally, our model suggests that neither of the intermediate targets often proposed for monetary policy—interest rates or money supply—may be closely related to what the government is ultimately interested in, and accordingly these intermediate targets should only be used with caution.

Third, our model explains why monetary policy seems to have such different effects in different sectors of the economy,³⁶ and why the interest rate charged borrowers in different sectors may change at different rates, or even in different directions. Our theory predicts that credit rationing may be more important in certain sectors than in others, and indeed a decrease in the availability of credit could be largely felt in a few sectors—those like home construction (i) which are higher leveraged, and (ii) which face (because of information asymmetries) equity and credit rationing.³⁷ Whether one wishes, as a matter of policy, to make those sectors bear the brunt of the required macroeconomic adjustments should be a subject for debate.

³⁶ Though in principle, the interest elasticity of different sectors may well differ, so that a given change in the interest rate would have a different impact on different sectors, interest elasticity itself should be derived from the demand elasticities and production functions of the different sectors. We doubt that there exist reasonable demand elasticities and production functions that would enable the observed patterns of responses can be accounted for within the traditional models. The empirical question is, do we believe, for instance, that the sensitivity of home construction to real interest rates is due to characteristics of the production function or to characteristics of the industry's financial structure, itself related to a variety of organizational factors. See Greenwald and Stiglitz (1988b).

³⁷ Even if credit rationing is prevalent in some industries because of information asymmetries, we have to argue that there are not good substitutes for credit, that is, firms cannot resort to the equity markets for raising needed capital. Greenwald, Stiglitz and Weiss (1984) and Myers and Majluf [1984], among others, provide explanations for 'equity rationing'. Their analyses also provides insights into what kinds of firms will most likely face equity rationing constraints.

Fourth, our model suggests that monetary policy may have a much larger effect on investment if the economy is in a boom with credit rationing regime than if it is not.³⁸

Fifth, one of the reasons that monetary policy has effects when it does is that other forms of credit are, for many borrowers, imperfect substitutes for bank borrowing (because of the differential information of the bank, and the problems associated with transferring information).

Concluding remarks

This paper has, we hope, made a contribution both to the microeconomic theory of market equilibrium with asymmetric information and to macroeconomic theory and policy. In most markets, asymmetric information—of both the moral hazard and adverse selection variety—is present and pervasive. We have shown that combining adverse selection and moral hazard considerations in the same model can lead to patterns of equilibria which differ from those which arise when either is present in isolation. Equilibrium may be characterized by complete or partial pooling; there may be (some) self-selection and rationing; and there may be rationing at *all* contracts.³⁹

Indeed, we have shown that there may be credit rationing at all contracts offered, even when collateral can, and is, used optimally (in conjunction with the other provisions of the loan contract, in particular, the interest rate charged) to differentiate among borrowers with differing probabilities of default. Credit rationing can occur if three conditions are satisfied:

1. There must be some residual uncertainty (information imperfection), after lenders employ whatever means they have at their disposal to differentiate among applicants and to control their behavior.⁴⁰
2. The adverse selection/adverse incentive effects of changing interest rates or the non-price terms of the contract (collateral, equity, etc.) must be sufficiently strong (at some values of the relevant variables) that it is not optimal for the lender to use these instruments fully to allocate credit.
3. The supply of funds must be such that at the Walrasian equilibrium (where demand equals supply, taking into account the use of non-price instruments), the expected returns to the lender are lower than for some other contract, at which there exists credit rationing.

³⁸ Our model is thus consistent with the observation that in recessionary periods, monetary policy often seems to have little effect (because of the excess liquidity in the banking system at the time, monetary policy has little effect on the availability of credit; and since credit is not constrained—borrowing is limited by firms' aversion to assuming additional risks—monetary policy can only attain its effects through the interest rate mechanism) while in other times, the imposition of a tight monetary policy seems to have large effects.

³⁹ This is in contrast with the simple models with only adverse selection or only moral hazard, where rationing occurred at most at one contract. See Stiglitz and Weiss (1981), the comment by Riley (1986) and our reply (1986).

⁴⁰ This includes not only the self-selecting mechanisms which have been the focus of this paper, but also auditing (direct examination).

The first condition, we would contend, is virtually always satisfied, but the second and third conditions may or may not be: we believe that credit markets are sometimes, but not always, characterized by credit rationing.⁴¹ When credit rationing is observed, it may be caused by other factors (such as legal restraints on the level of interest rates charged). But there are circumstances in which credit rationing occurs at interest rates below legally imposed ceilings.

Further, the comparative statics of these markets (with adverse selection and moral hazard, with or without credit rationing) look markedly different from those associated with standard markets, and it is these comparative static propositions which provide the bridge between the macroeconomic and microeconomic analyses.

It should be stressed that the major differences between the comparative static properties of our model and other macroeconomic models continue to hold even if the economy is *not* in a rationing regime. These differences and the different effects of monetary policy in our model arise from the sorting and incentive effects of contracts, not from credit being rationed.

Standard representative agent models find it difficult to explain in a consistent manner the patterns of movements in productivity, real interest rates paid depositors and charged borrowers. The analysis here, as in much of other recent work on capital market imperfections, is predicated on the proposition that asymmetric information is particularly important in capital markets, that debt and equity contracts are different, and that understanding these differences is critical to understanding cyclical variability. Here, we have stressed the fact that interest rates charged need not, and will not in general, move in a way closely linked to movements in productivity. To put it somewhat loosely, the fraction of the total returns to an investment project which can be captured by lenders can vary over the business cycle, and indeed can vary depending on the source of the original shock to the economy.

The discrepancy between the return to the bank and total returns to investment projects has important welfare implications: it means not only that banks, in the process of sorting among potential borrowers, do not necessarily choose those loans with the highest total returns, but it also means that when credit is restricted, as through monetary policy, it is not necessarily the projects with the lowest return which are terminated.⁴²

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APPENDIX A

Effects of cyclical changes in productivity on interest rates charged: partially separating equilibrium

1. *Balanced productivity changes*

In the case of balanced productivity changes (described in Section 2.1.a), the contracts offered ($\{F\}$)

⁴¹ We can show that if the first two conditions are satisfied, then there always exists some credit supply functions for which credit rationing will occur.

⁴² More generally, it can be shown that market equilibrium is not even *constrained* Pareto optimal.

and $\{G\}$ will remain unchanged. Since the return of G has increased, the return at $\{F\}$ must have increased. To see what happens to the fraction $\{F\}$ who are poor, we observe that for $v\{F\}$ to equal $v\{G\}$

$$[\beta p^s x + (1-x)\beta p^r](1+r_F) + (1-(\beta p^s x + (1-x)\beta p^r))C_p = \beta p^r(1+r_G) + (1-\beta p^r)C_r,$$

(where r_F and r_G are the rates of interest in contracts $\{F\}$ and $\{G\}$ respectively), from which it follows that

$$\beta \, dx/d\beta = -[C_r - C_p]/(p^{s*} - p^{r*})(1 + r_F - C_p) < 0,$$

ie, when β increases a smaller fraction of the rich get loans at contract $\{G\}$ so that a larger fraction accept contract $\{F\}$. The intuition is as follows: An equi-proportionate increase in success probabilities decreases the value of collateral to the lender. Because G loans demand more collateral than F loans, an increase in β has a smaller effect on the profitability of $\{G\}$ loans than of $\{F\}$ loans. If both F and G loans are to continue to be made, the increased profitability of F loans must be offset by an increase in the proportion of rich borrowers choosing F loans, ie, x must decrease.

Since $v\{G\}$ is increased, the interest rate paid depositors is increased, and so is the aggregate quantity of loans. If this effect is not sufficient to eliminate rationing at contract G , both the proportion and absolute number of G loans would fall as banks making F loans are able to compete more aggressively for borrowers. Hence the average interest rate charged and average interest rate paid both increase with β (move procyclically).

2. Unbalanced changes in success probabilities.

Under the assumptions given in Section 1.3.c, for a partially separating rationing equilibrium, the interest rates on both contracts $\{F\}$ and $\{G\}$ decrease when the success probabilities of risky projects have a greater percentage increase than the success probabilities of safe projects. We argued that these disproportionate changes are characteristic of booms. But the decrease in the interest rate at $\{G\}$ may either exceed or be less than at $\{F\}$.

As we see from (10), depending on differences in non-collateralizable wealth between the rich and poor relative to their differences in collateralizable wealth and differences in their risk aversion, interest rates at the high collateral contract could fluctuate more or less over the business cycle than interest rates at the low collateral contract.

As before, the returns at $\{F\}$ and $\{G\}$ are altered, but by differing amounts. Hence, for the return at $\{F\}$ to equal the return on $\{G\}$, the fraction of loans made at $\{G\}$ will have to adjust, but it is ambiguous whether it will increase or decrease. Accordingly, although there may be some presumption that the average rate of interest charged will decrease in a boom, it is possible that if the proportion of the rich getting loans is decreased enough, then the average rate of interest charged borrowers will actually increase.⁴³

For sufficiently 'unbalanced' changes in productivity, interest rates paid depositors may fall, i.e.

$$\beta \frac{dv}{d\beta} = p^{r*} \left(1 + r_G - C_p + \frac{\partial \ln \delta}{\partial \ln \beta} \frac{dr_G}{\partial \ln \delta} \right) < 0$$

if

$$\left| \frac{\partial \ln \delta}{\partial \ln \beta} \right| > \frac{1}{\frac{d \ln(1+r_G)}{d \ln \delta} \frac{1}{1 - (C_p/(1+r_G))}}$$

Our discussion in this section has been predicated on the changes in productivity being sufficiently small that there is no change in regime. Of course, with large productivity shocks, the economy may go from a situation where there is credit rationing, to one where there is not, or conversely.

⁴³ It is possible that, as the economy enters a recession, the proportion of loans made at contract $\{F\}$ increases. This is particularly striking, given that in slumps the (social) productivity of the risky technique is particularly low relative to that of safe techniques, and only loans at contract $\{F\}$ are financing the risky technique.

APPENDIX B

Comparative statics analysis of effects of changes in supply of loanable funds

Case 1

Rich borrowers prefer contract $\{F\}$ to $\{G\}$, and $v(G) > v_z(F)$. (i) Let us suppose that initially there is an excess demand for credit (by rich borrowers) at contract G : $L(v(G)) < N_r$. The equilibrium is then characterized by only contract G being offered. (ii) Now let us consider an outward shift in the supply of loanable funds function so that $L(v(G)) > N_r$. Banks will then compete for rich borrowers by moving the contract they offer rich borrowers southwest along the switch line of the rich borrowers. (For expositional simplicity, we restrict our analysis throughout this Appendix to cases in which the high collateral contract requires more than C_p of collateral.) This movement continues until a contract is reached such that $v(H) = v_z(F)$. (iii) Suppose rich borrowers prefer contract $\{F\}$ to $\{H\}$. Then further outward movements in the supply of loanable funds function will cause contract F to be offered; the number of contract F loans offered will be such that when all rejected rich borrowers get credit at contract H , the quantity of loans made is equal to $L(v(H))$. (iv) Further outward shifts in the loanable funds function will first eliminate rationing at contract F . There will then be a complete pooling equilibrium. Still further increases in supply will result in a southwest movement along the switch line of the poor borrowers. We denote this contract by \hat{F} .⁴⁴ (v) If the utility function of borrowers is characterized by decreasing absolute risk aversion, the indifference curves of the rich borrowers become flatter as they become better off. Consequently, there may be a supply function of funds for which there exists a contract \hat{H} along the rich individual's switch line such that

$$v_z(\hat{F}) = v(\hat{H})$$

and

$$EU'(\hat{F}) = EU'(\hat{H}),$$

and

$$L(v(\hat{H})) = N$$

the rich borrowers are indifferent between the high and low collateral contracts, both of which yield the same return to the bank.

At that point further outward movements in the supply of loanable funds function would be accompanied by some rich borrowers choosing high collateral contracts in preference to low collateral contracts. The greater is the proportion of rich borrowers choosing the high collateral contract, the greater is the proportion of poor borrowers among those choosing the low collateral contract, and consequently the higher is the return on that contract. The contract pairs, and choices of rich borrowers would then be such that rich borrowers are indifferent between the contract being chosen, and banks make the same return on the two contracts, ie, the contract pairs will lie on the indifference curve of rich borrowers through the high collateral contract, and the ratio of rich borrowers choosing the high collateral contract in preference to the low collateral one will be such as to equate the return to a bank from the two contracts.⁴⁵

Case 2

Rich borrowers prefer contract $\{G\}$ to contract $\{F\}$, $v(G) > v_1(F)$ and $L(v(G)) < N$. Initially, only G is offered. As the supply of funds function shifts outward, eliminating rationing, the contract being offered moves along the switch line of the rich borrowers until some contract H is offered such that $v(H) = v_1(F)$.

Since the rich prefer $\{H\}$ to $\{G\}$ to $\{F\}$, they prefer $\{H\}$ to $\{F\}$; if contract $\{F\}$ is offered as well as contract $\{H\}$, contract $\{F\}$ is only chosen by the poor borrowers. Further outward movements of the loan supply function would first cause an increase in the number of loans made at contract F , and then southwest movements of both the low and high collateral contracts along the switch lines of the poor and rich borrowers.

⁴⁴ We note the possibility that the indifference curve through \hat{F} for the poor individuals may be flatter than that of the rich (at higher levels of collateral).

⁴⁵ That is $v_x(\hat{F}) = v(\hat{H})$ for some $x \geq z$ and $EU'(\hat{F}) = EU'(\hat{H})$.

Case 3

Finally, let us consider the case where rich borrowers prefer contract G to F but $v_z(F) > v(G)$, and $L(v_z(F)) < N$. Then the equilibrium is characterized by only contract F being offered. Starting at this equilibrium, outward shifts in the supply of loanable funds function first reduce and then eliminate rationing at F . Further outward shifts cause banks to move the contract they offer southwest along the switch line of the poor borrowers until contract F' satisfying $v_z(F') = v(G)$ is reached. At that point, if the rich borrowers prefer F' to G , a single contract continues to be offered and outward shifts to the loan supply function continue to cause southwest movements of the contract along the switch line of the poor borrowers.

On the other hand, suppose the rich borrowers prefer G to F' . Consider a contract F'' along the poor's switch line, such that $v_1(F'') = v(G)$. If rich borrowers prefer G to F'' , then both contracts would be offered in equilibrium. All the rich borrowers choose G and all the poor borrowers choose F'' . Further outward shifts in the loan supply function cause southwest movements of the two contracts along the switch lines of the poor and rich. At all points, the contracts generate the same return. Only poor borrowers choose the low collateral contract. Rich borrowers choose the high collateral contract.

If the rich borrowers prefer F'' to G then some contract F^* lying on the switch line of poor borrowers between F' and F'' is offered such that the rich borrowers are indifferent between this intermediate contract and contract G . In equilibrium, the proportion of rich borrowers choosing G when offered F^* is such that the two contracts generate the same returns to banks. Further outward shifts in the supply of funds function would then cause southwest movements along the two switch lines. The contract pairs lie on the same indifference curve of the rich borrowers. The proportion of rich borrowers choosing the low collateral contract is such that the two contracts generate the same expected return to a bank.

APPENDIX C

Multiple contract equilibria

In the text, we restricted the analysis to the case where each bank offers a single contract. In this appendix, we extend the analysis to the case where each bank can offer multiple contracts. We show that the equilibria we derived in the text remain equilibria under this expansion of the admissible strategies. This change in the admissible strategies may result in their being additional equilibria. We do not pursue that possibility here.

In the case where banks can offer more than one contract, borrowers face a more difficult problem: assuming that the bank knows all the contracts for which a borrower has applied, the bank may make inferences based on those applications. The borrower then has to make an inference about what the bank will do if he applies for, say, two loans; this will, presumably, depend on what inferences the bank makes about the type of individual that applies for two loans. Since what will be critical in determining the nature of the equilibrium is beliefs about out of equilibrium moves, it is in this case that the variety of refinements of Nash equilibrium become important.

To see that the pooling equilibrium of Section 1.3a, with each bank offering a single contract, can easily be supported as a Nash equilibrium, consider a bank deviating from this equilibrium by offering several contracts.

Clearly in this case there are beliefs that would deter a bank from making that deviation. For instance, suppose all potential borrowers thought that the bank believed that borrowers that apply for any contract other than the lowest collateral one are rich. Because in the pooling equilibrium with rationing the return paid depositors is $1 + i = v_z(F) > v(G)$, loans to rich borrowers generate losses; therefore, the belief that only rich borrowers apply for the higher collateral loans would lead borrowers to the further belief that if they applied for one of the high collateral contracts, the bank would not lend to them at any contract. Consequently, no borrowers would apply for the higher collateral contract, and offering more than one contract would be equivalent to offering only the lowest collateral contract. (Note that if a bank could commit itself to financing a fixed percentage of the applications for high-collateral-low-interest-rate loans, then the pooling equilibrium with rationing could always be broken. We do not consider it realistic to expect commitments of that sort to be enforceable.)

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